California Division of Mines and Geology

Fault Evaluation Report FER - 194
Peralta Hills Fault
Orange County

by

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INTRODUCTION

A thrust fault along the south side of the Peralta Hills, Orange Quadrangle, Orange County was briefly evaluated in FER-42 (Smith, 1977) and its Supplement No. 1 (Hart, 1978). This thrust fault, now called the Peralta Hills fault (Bryant and Fife, 1982), was judged to be not sufficiently active or well defined for zoning under the Alquist-Priolo Special Studies Zone Act (Hart, 1985). The Norwalk and El Modeno faults were also judged to be neither well defined nor sufficiently active for zoning (Smith, 1977). These evaluations (Smith, 1977; Hart, 1978) were based almost entirely on a review of the available literature; neither interpreted pre-development aerial photos.

As the area along the fault has been developed, geological consultants have studied the Peralta Hills fault in several locations (Fugro, 1972; Geotechnical Consultants, 1976; GeoSoils, 1978; Converse Ward Davis Dixon, 1979a,b; Leighton and Associates, 1983, 1986). Development along the fault and a summary by Bryant and Fife (1982) concluding that the fault is active has prompted a re-evaluation of the Peralta Hills fault. This report includes evaluation of published and unpublished data not available to Smith (1977) or Hart (1978), evaluation of pre-development aerial photos, and field checking of several localities.

SUMMARY OF AVAILABLE DATA

Geologic Setting

The Peralta Hills lie at the northwestern edge of the Peninsular Ranges province and the eastern edge of the Los Angeles Basin. The south limb of a large westerly plunging syncline with an axis approximately along the Santa Ana River Canyon forms a rounded ridge between the Santa Ana River on the north and Santiago Creek on the south. Topographically the hills consist of a single east-west trending ridge with a relatively gentle north slope and a steeper south slope. Slopes are controlled by bedding in the Miocene Puente Formation, which forms gentle northward-sloping dip-slopes and steep south-facing bluffs. Undifferentiated Sespe-Vaqueros Formation and Topanga Formation (mostly sandstones) crop out on the south side of the hills. Four Quaternary terrace deposits were mapped by Schoellhamer and others, (1954, 1981) overlying the bedrock units on the south side of the hills (Figure 1). These terrace deposits consist of sand and gravel and are yellowish to reddish brown in color. They are thought to be of late Pleistocene age except for the lowest terrace (Qoa1), which may be of Holocene age (Schoellhamer and others, 1981).

These terraces form a succession of flat lying deposits with the oldest (Qoa4) highest on the slope and the youngest (Qoa1) adjacent to the modern channel of Santiago Creek on the south side of the hills. At the upper end of the oldest terrace, Schoellhamer and others (1954, 1981) map "deformed alluvial deposits" (Qda) offset by the Peralta Hills fault. These deposits are shown to be overlain by the oldest terrace deposits (Qoa4) and therefore, are thought to pre-date the upper Pleistocene terraces of Santiago Creek. Later work by Fugro (1972) and Leighton and Associates (1987) concluded that these (Qda) were Qoa4 not older deposits.

Peralta Hills Fault

Schoellhamer and others (1954, 1981) map a thrust fault on the south side of the Peralta Hills from the slopes above Cerro Villa Heights for about 1 mile to the east (Figure 1). Earlier mapping of the area by Richmond (1952) did not show any thrust faulting. The thrust fault places Puente Formation over the Topanga Fm and "deformed alluvial deposits" on a plane that strikes approximately east-west and dips to the north. At one well-exposed location the fault strikes N27°E. dips 42°N. and contains 2 to 10 cm of gouge. Schoellhamer and others (1981) apparently did not consider this fault a major feature; it is only discussed in relation to the deformed alluvial deposits and is not projected onto a cross-section drawn just to the east of the end of the surface trace. Schoellhamer and others map several other faults in the area, including one which offsets the thrust fault. These faults are mostly northwest trending normal faults with east side down displacement. There are also several northeast trending faults with north side down displacement. These faults are generally short features with minor displacement.

The major fault in the area mapped by Schoellhamer and others (1981) is the El Modeno fault, a southwest-dipping normal fault which follows the south side of the Peralta Hills for part of its length (Figure 1). This fault is concealed for most of its length but is intersected by a least two oil wells. Subsurface control enabled Schoellhamer and others (1981) to show that this fault offsets the base of the La Habra Formation (lower Pleistocene) by about 1,500 feet (450 m).

Mapping by Morton and others (1976) and Morton and Miller (1981) is generally similar but extends the thrust fault westward about 1 mile along the north edge of Cerro Villa Heights. Morton and Miller show Puente Formation thrust over Quaternary terrace deposits including those mapped as Qda, Qoa2 and Qoa4 by Schoellhamer and others (1981). Morton and others consider the thrust fault a potential seismic hazard based partly on the work of Fugro (1972).

Bryant and Fife (1982) present a different interpretation of the faulting in the Peralta Hills (Figure 2). They suggest that the fault along the south side is a thrust fault, not the El Modeno fault, and is continuous with the thrust fault above Cerro Villa Heights mapped by Schoellhamer and others (1981) and Morton and Miller (1981). Bryant and Fife also extend this fault 2 miles to the east of the end of the fault mapped by Schoellhamer and others and Morton and Miller. Bryant and Fife name this fault the Peralta Hills fault.

Bryant and Fife (1982) also differ markedly with previous workers on the activity of this thrust fault. They conclude, based on their own work (Converse Ward Davis Dixon, 1979a,b) and work by other consultants, notably Fugro (1972), that the fault has ruptured the ground surface in Holocene time. Bryant and Fife recognize the possibility that the Peralta Hills fault could be a flexural slip fault and therefore not a source of seismic activity but suggest that it is probably a deep seated feature capable of moderate earthquakes and ground rupture. They suggest that a reverse fault dipping 60 degrees north is consistent with the subsurface data of Schoellhamer and others (1981). This relatively steep dip could explain the failure of any oil wells to intersect the fault. The fault and missing section in the two wells south of the El Modeno fault would then have to be due to other unrelated faulting.

Detailed Investigations

As the Peralta Hills have been developed, geological consultants have investigated several segments of the Peralta Hills fault. These are shown on Figure 3 and will be discussed from west to east. A tract just east of the Newport Freeway and on the Peralta Hills fault of Bryant and Fife was investigated by John D. Merrill Inc., (1971). No fault was located in field mapping or by shallow auger holes, but no trenching was done.

Immediately east of this site Converse Ward Davis Dixon (1979a) investigated a proposed water tank site (Segment 1 on Figure 3). Here, trenching showed Puente Formation siltstone reverse-faulted over terrace deposits (Figure 4). In trenches 3 and 4 (locality 1, Figure 3) the fault is shown to dip 55° N to 57° N. with Puente Formation siltstone displaced over gravel (Qoa2 of Schoellhamer and others, 1981). The fault is projected upward as a thrust through two soil units, apparently based on a soil color change in trench 3 and the apparent truncation of a lower soil. Trench 4 also shows a soil step, but the fault is not projected to the surface (Figure 4). Converse Ward Davis Dixon did not identify any shears in the soil but concluded that the fault had offset the soil. Roy Shlemon also observed the trench exposures in 1979 and concluded that the faulting was Holocene based on subtle geomorphic features and offset soils of mid-Holocene age (personal communication, 1987). Although the log of trench 3 does show apparent offset of soils, the sense of offset is down to the north, which is inconsistent with thrusting. This suggests that differential soil development or soil creep could be the cause of the apparent soil offset.

East of the water tank site, the fault has not been mapped in detail for approximately 2,000 feet. Continuing to the east the fault has been mapped across a series of residential tracts by Geotechnical Consultants Inc (1976), GeoSoils (1978), Converse Davis Dixon Associates (1976), Converse Ward Davis Dixon (1979b) and Leighton and Associates (1985, 1986). Geotechnical Consultants mapped about 2,000 feet of the thrust fault (Segment 2 on Figure 3) during grading. They state that "The fault does not cut terrace deposits nor topsoil" and that "The maximum amount of displacement, assuming a correlation of lower surfaces of terrace deposits, is on the order of 40 feet." Although these statements are conflicting, Puente Formation siltstone is shown to be thrust over Quaternary terrace deposits on the geologic map. No evidence is presented to suggest Holocene movement. Geotechnical Consultants also note that the trace of the fault follows the crest of a ridge, implying that the fault is not controlling the geomorphology. The adjoining tract to the east was mapped by GeoSoils (1978) (Segment 3 on Figure 3). The text of this report was missing from the files at the City of Orange, but the map was found and the trace transferred to Figure 3. The map shows Puente Formation thrust over Quaternary terrace deposits.

The next tract to the east (Segment 4 on Figure 3) has been studied by Converse Davis Dixon Associates (1976), Converse Ward Davis Dixon (1979b) and Leighton and Associates (1985, 1986). The original geotechnical report by Converse Davis Dixon Associates found no faulting despite 24 backhoe trenches and three bucket auger borings. Faulting was found during grading, however, and was then evaluated by Converse Ward Davis Dixon. Based on further trenching, Converse Ward Davis Dixon concluded that the Puente Formation had been thrust up to 50 feet over Holocene slopewash. The geometry of the faulting is complex, however, as shown in the log of dozer trench 5 (Figure 5) (locality 2, Figure 3). The fault exposed deepest in the trench dips gently to the north. As it approaches the surface it bends to horizontal and then to a southward-dipping plane. Several landslide planes are exposed in this trench, the deepest of which is shown to merge with the fault near the bottom of the trench. The plane extending from this point to the surface is shown to be a fault plane and all movement on it is assumed to be due to faulting. Three samples for Carbon-14 dating were recovered from slopewash beneath the southward dipping part of this plane. These samples were dated at 3,000 to 3,500 years B.P.. Converse Ward Davis Dixon and Bryant and Fife (1982) conclude that this demonstrates Holocene faulting. Converse Ward Davis Dixon calculate a slip rate of 1.4 feet/100 years (4.2 mm/yr) for the fault based on 50 feet of offset of 3,500 year old slopewash.

Leighton and Associates (1986) performed further trenching in the same area. Based on exposures essentially identical to those observed by Converse Ward Davis Dixon they concluded that the landslide plane truncates the fault plane and the Carbon-14 samples were probably recovered from beneath or within the landslide. Leighton and Associates conclude that the 3,500 year B.P. carbon dates represent the latest movement on a large landslide. They found no evidence for Holocene fault movement.

The area along the Peralta Hills fault east of the residential tracts (Segment 5 on Figure 3) has been studied for the Southern California Edison Co. Serrano Substation (Fugro, 1972) and for residential development around the substation (Leighton and Associates, 1987). Fugro mapped the main trace and several northwesterly trending faults south of the main trace of the Peralta Hills Fault. The main thrust fault strikes N50°W to N50°E and dips 8 to 35 degrees to the north. Puente Formation siltstone has been thrust at least 40 feet over Quaternary terrace deposits (the "deformed alluvium" of Schoellhamer and others, 1981). Unfortunately neither Fugro or Leighton and Associates were able to find datable younger deposits along this fault, though both did map three landslides over the fault.

Several other faults which cut Quaternary terrace deposits were mapped by Fugro (1972). Those faults which have some indications of Holocene movement are shown on Figure 3 and are discussed here. These include northwesterly striking thrust faults similar to the main thrust fault and subparallel normal faults. Of these, one normal fault, Fault F offsets Quaternary terrace deposits by about 6 inches, down to the north and could be traced as soil-filled fractures to within six inches of the ground surface. Fugro (1972) states that this "suggests Fault F ruptured the ground surface probably within the past few hundred years". Similarly, another normal fault, Fault D (Figure 3) offsets Quaternary terrace deposits 4.5 feet, down to the north and can be traced into slopewash overlying terrace deposits as a "wedge shaped streak of brown sandy clay". Although Fugro (1972) states that this implies "possible ground rupture in near historic time" their trench log shows the clayey zone only extending to the top of the terrace deposit. Clear evidence for Holocene fault movement such as shears or offsets within the slopewash were not noted from trenches across this fault.

A thrust fault (Fault C on Figure 3) is reported by Fugro (1972) to offset the terrace deposits (Qoa4) at least 25 feet and extend upward into the overlying alluvial and colluvial units. This fault is a north-dipping thrust subparallel to the main fault. It dies out approximately 15 feet below the surface in the lower part of this alluvium at locality 3, Figure 3. Although Fugro claimed that this offset was "conclusive proof of recent activity" no attempt was made to date the alluvium.

Leighton and Associates (1987) re-investigated the area studied by Fugro (1972). They trenched the faults mapped by Fugro, and mapped several others based on interpretation of aerial photographs and on field studies. Clear evidence for Holocene faulting was not found by Leighton and Associates although stone lines in the colluvium overlying Fault 3, a south dipping normal fault, and Fault 5, a north dipping thrust, (Localities 4 and 5, Figure 3) appear to be offset. In both cases, Leighton and Associates describe well-developed caliche and red-brown color of the offset soils, probably indicating a pre-Holocene age for the offset units.

Fault 3 of Leighton and Associates appears to be a continuation of Fault C of Fugro. If so, the offset alluvial and colluvial units which Fugro assumed to be Holocene may be roughly correlative with or older than the Pleistocene soils described by Leighton and Associates.

East of the Serrano Substation site the Peralta Hills fault has not been mapped in detail. Schoellhamer and others (1981) and Morton and Miller (1981) map several minor northeast and northwest trending faults with varying senses of offset. Bryant and Fife (1982) show a single throughgoing thrust fault extending for about 2 miles east of the Serrano Substation but provide no evidence for this previously unmapped portion of the fault. Schoellhamer and others and Morton and Miller also show the thrust fault offset by a northwest trending normal fault immediately east of the Serrano Substation (Figure 1).

AERIAL PHOTO AND FIELD INTERPRETATION

Aerial photos taken by Fairchild Aerial Surveys, Inc. in 1927, 1939, and 1961 and by the USGS in 1982 were examined to evaluate the Peralta Hills Fault for geomorphic evidence of recent faulting. The 1939 photos provide the best pre-development coverage. They show broad gradual breaks in slope along segments 3, 4, and 5, which is essentially the same as the trace mapped by Morton and Miller (1981). These breaks in slope generally parallel the fault mapped by various consultants but are not continuous and tend to be upslope from the trace mapped by consultants. These and other features that could be interpreted as fault related topography are shown on Figure 3.

Light tonal lineaments occur along parts of segments 3, 4, and 5. These partly coincide with the traces of the fault as mapped by various consultants. These tonal features may be a caliche zone along the fault exposed at the surface by erosion. No scarps or topography suggestive of recent faulting was observed along these tonal features either on aerial photos or on segment 5 in the field.

The features shown on Figure 3 are locally consistent with thrust faulting but are neither sharp nor continuous. Any faulting which may have caused this morphology was probably not Holocene. Additionally, few of the geomorphic features correspond with mapped faults. The trace of the Peralta Hills fault is not defined by geomorphology suggestive of Holocene faulting.

Segment 4 of the fault was observed in the field on January 12 and 13 and March 15, 1988 (Figure 3). Grading on this tract was in progress and numerous dozer cuts and shallow trenches were open. A cut slope near the location of Dozer Trench 5 (locality 2, Figure 3) showed the critical area where the landslide plane intersects the fault plane (Figure 5). Numerous zones of shearing were observed along and above the fault plane. All of the shear planes observed had slickensides indicating downslope movement. The horizontal fault plane logged by Converse Ward Davis Dixon (1979b) (Figure 5) appeared to be a zone where numerous landslide planes converge. It was not possible to determine from the available exposures how much of the shearing was due to faulting and how much due to landsliding.

A clear exposure of a thrust fault entirely in Puente Formation siltstone was found 2,000 feet to the southwest at locality 6 (Figure 3). The fault here strikes approximately east-west and dips approximately 10° to the north. Folding within the Puente Formation indicates southward thrusting but the exposure is adjacent to a cut slope and all of the surficial deposits have been removed, preventing any evaluation of the recency of faulting.

In Segment 5 (Figure 3) parts of the fault can be generally traced on the ground, as on the air photos, by a break in slope trending easterly. On the ridge north of the Serrano Substation, Puente Formation is thrust over older alluvium (locality 7, Figure 3). The fault is exposed in outcrop as a sheared zone with abundant caliche but has no topographic expression. Nearby the fault has been displaced by a landslide but is visible as a caliche rich band in the landslide deposits. The landslide shows relatively fresh topography, and is probably of Holocene age, but clearly post-dates the latest faulting.

SEISMICITY

Seismicity of the northeastern Orange County area is shown on Figure 6. A and B quality epicenters are for the period 1932 to 1985. The northeastern third of the Orange Quadrangle is seismically active but seismicity is not clearly confined to discrete zones. Although microseismicity along and north of the Peralta Hills fault could be due to movement on the fault, such movement is not required by the seismicity.

CONCLUSIONS

The Peralta Hills fault is an approximately east-striking north-dipping thrust fault which has displaced Miocene Puente Formation at least 40 feet over Quaternary older alluvium. The lack of subsurface data on the fault and its position on the south limb of a syncline are consistent with flexural slip. A deep-seated reverse fault with a dip of greater than 60° could also fit the available data. However, the fault zone was not reported in any of the exploratory wells drilled in the area. The total displacement on the fault is unknown.

Parts of the Peralta Hills fault have been mapped by various consultants. Geologic field mapping, with preliminary subsurface investigations was not sufficient to locate the fault in at least two cases (Merrill, 1971; Converse Davis Dixon Associates, 1976). In several other cases the fault was mapped accurately only after it had been exposed by grading (Geotechnical Consultants Inc, 1976; GeoSoils, 1978; Converse Ward Davis Dixon, 1979a,b). Only segment 5 was well enough defined to be observed and mapped before grading (Schoellhamer and others, 1981). The distal ends of the Peralta Hills fault, which have not been investigated in detail, remain poorly defined and somewhat speculative.

Holocene movement of the Peralta Hills fault has been proposed at two locations. On segment 1 Converse Ward Davis Dixon (1979a) propose thrust faulting of Holocene soils. Their trench logs, however, show a soil step which could be interpreted as differential soil development, colluvium deposition on irregular topography, extension at the head of a landslide or down to the north normal faulting. Holocene thrust faulting is not consistent with the features logged in the trenches (Figure 4). On segment 4 Converse Ward Davis Dixon (1979b) proposed that Puente Formation has been thrust 50 feet over Quaternary slopewash. Their trench logs, however, show landslide debris over slopewash (Figure 5). It is impossible to determine from these trench logs or from exposures observed in 1988 how much, if any, of this offset is due to faulting. Leighton and Associates (1987) performed a similar trenching and mapping investigation and concluded that there is no evidence for Holocene faulting in the area investigated by Converse Ward Davis Dixon (1979b).

Fugro (1972) proposed Holocene offset of several subsidiary faults south of segment 5. Of these, offset on Fault D and Fault F were based on anomalous features in the soil which do not necessarily indicate faulting. Offset on Fault C is clear but dies out 15 feet below the surface in undated alluvial and colluvial units. Colluvial units described nearby by Leighton and Associates (1986) have well developed caliche coatings on clasts and red brown color. This suggests that the colluvium described by Leighton and Associates and the much thicker sequence described by Fugro are of pre-Holocene age.

The trace of the Peralta Hills fault proposed by Bryant and Fife (1982) is only generally defined by the base of the hills, breaks in slope and tonal lineaments. Where detailed mapping has been done, however, the fault does not follow the base of the hills and follows a break in slope only at one location. Where tonal lineaments coincide with fault segments 3, 4 and 5, they do not have any topographic expression. Based on its geomorphic expression, it seems unlikely the Peralta Hills fault could have had significant displacement in Holocene time, as proposed by Bryant and Fife (1982).

RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1985). The Peralta Hills fault from the Orange Reservoir water tank site to the eastern end of the fault mapped by Morton and Miller (1981) has been partly defined by mapping and subsurface investigations, but is poorly defined geomorphically. Although Holocene rupture of portions of this segment has been proposed (Fugro, 1972; Converse Ward Davis Dixon, 1979a,b; Bryant and Fife, 1982) the evidence for Holocene rupture is not convincing (Leighton and Associates, 1986, 1987). The Peralta Hills Fault should not be zoned under the Alquist-Priolo Special Studies Zone Act.

Report & Recommendations reviewed & approved. Earl W. Hart 5/18/88

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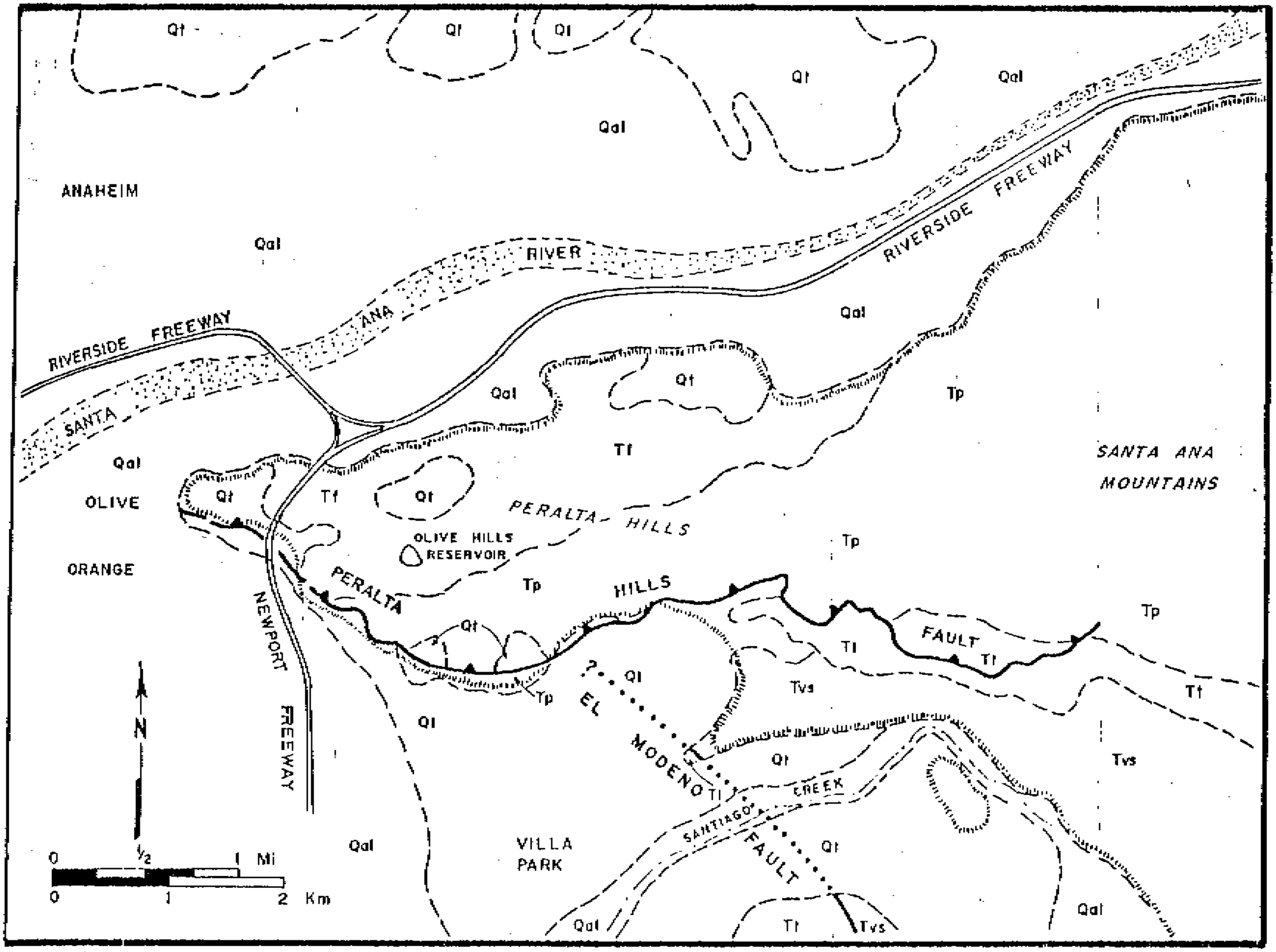

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Figure 2. Generalized geologic map of Peralta Hills modified from Morton and Miller)1981). Qal = alluvium, Qt = terrace deposits, Tf = Fernando Formation, Tp = Puente Formation, Tt = Topanga Formation, Tvs = Vaqueros-Sespe Formation, = reverse fault, = normal fault (dotted where burried), = contact, = edge of hills. From Bryant and Fife (1982)

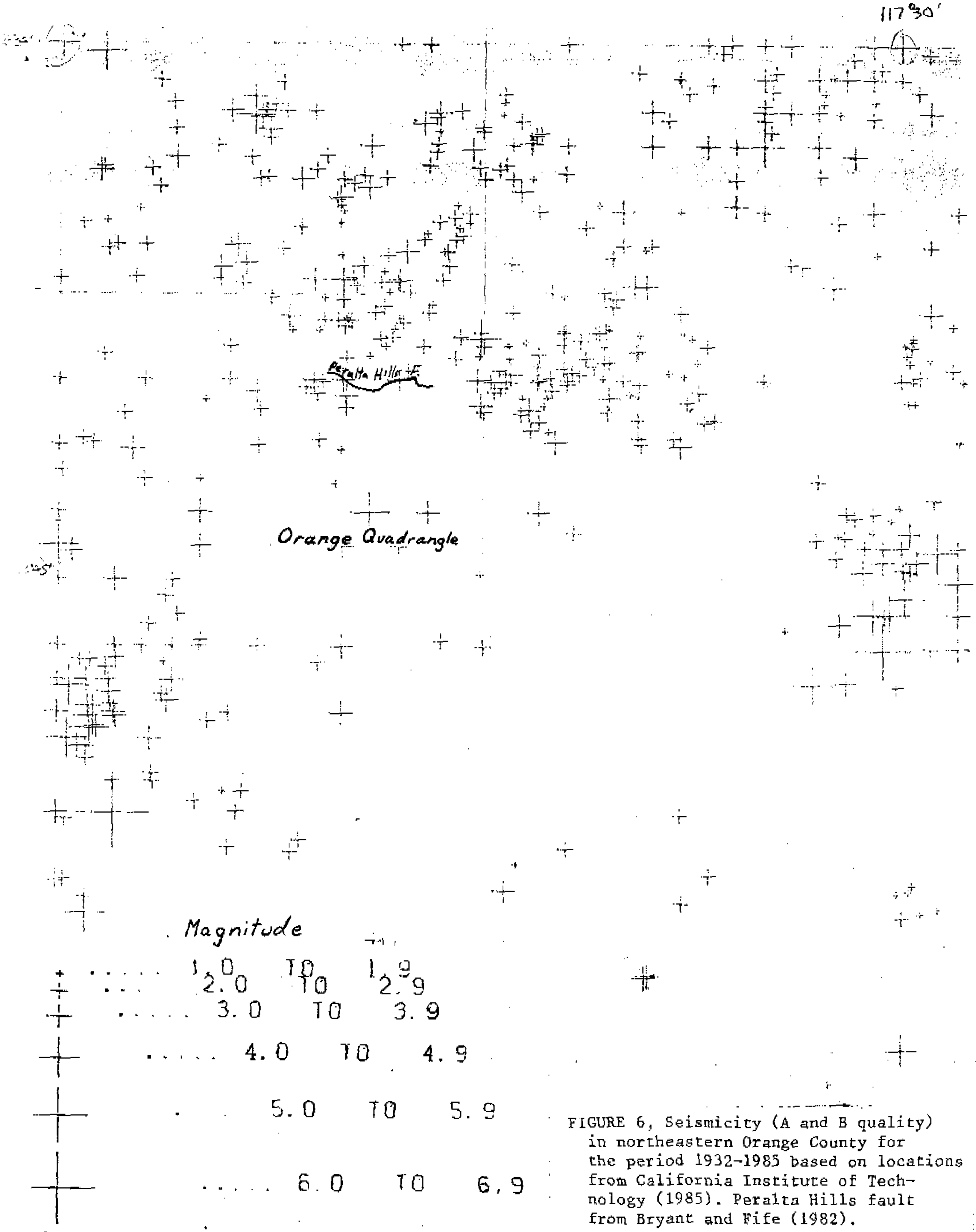
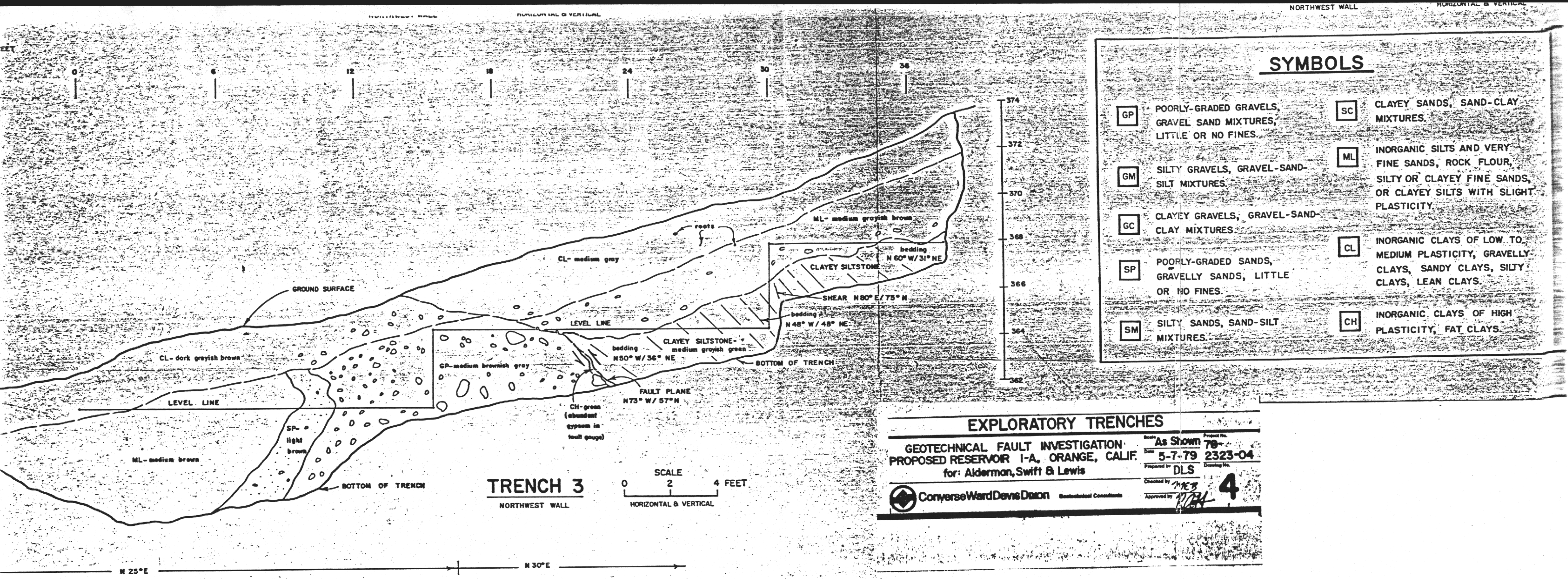


FIGURE 6, Seismicity (A and B quality) in northeastern Orange County for the period 1932-1985 based on locations from California Institute of Technology (1985). Peralta Hills fault from Bryant and Fife (1982).



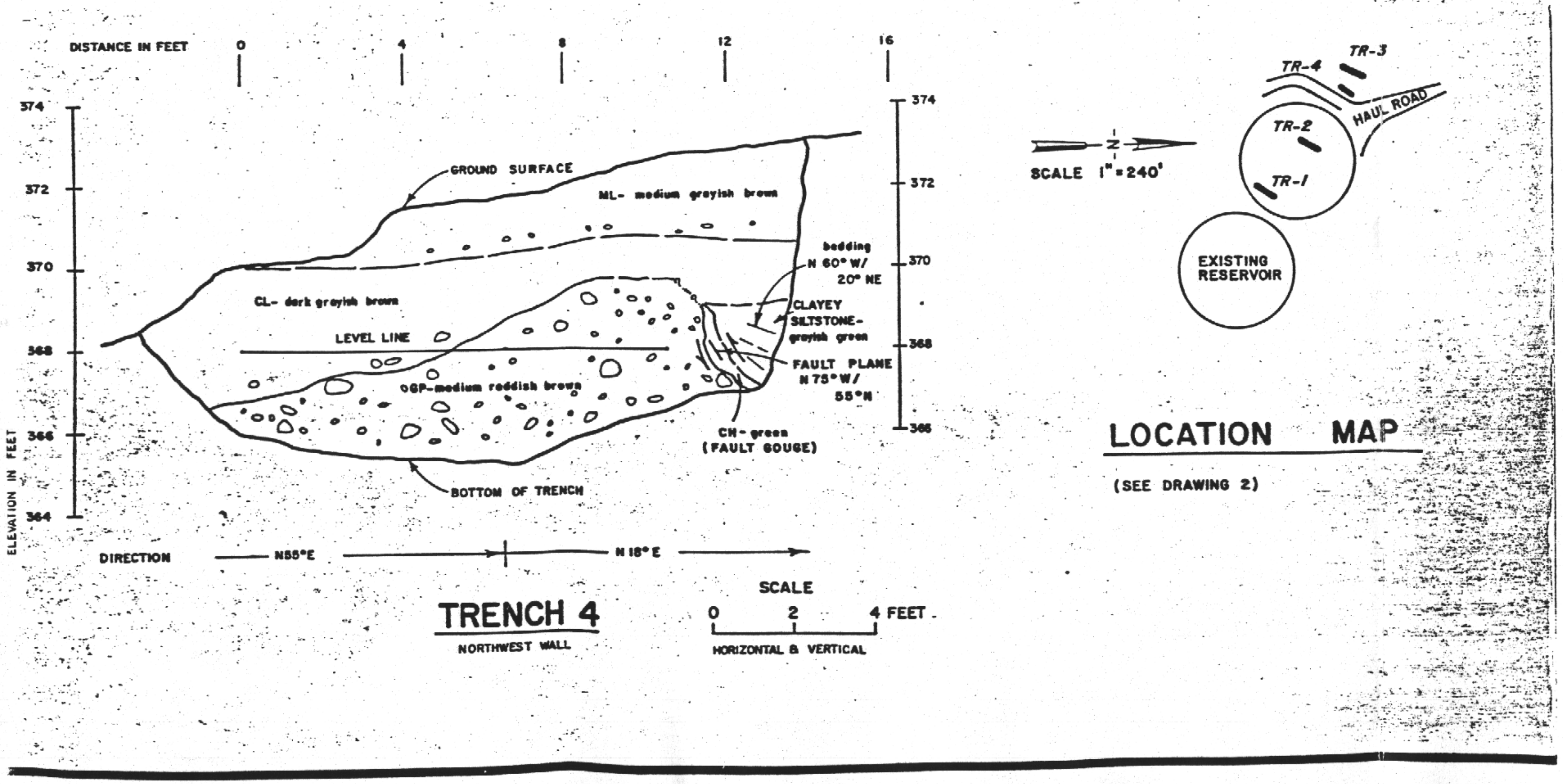


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FIGURE 4. Trench logs by Converse Ward Davis Dixon (1979a) at locality 1, Figure 3. Note change in soil color above fault in trench 3 and relative elevations of bedrock and terrace deposits in both trenches.